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Re: PR Docket No. 93-61, RM-1919: Discussion of Global Positioning System (GPS)-based Automated Vehicle Location (AVL) and Real-Time Kinematic (RTK) Systems and Comparison to Automated Vehicle Monitoring (AVM) Systems [Pulse-Ranging Hyperbolic Multilaterations (Ground-Based Radio Triangulation)]

Dear Commissioners:

The intent of this presentation is to provide information on alternative location techniques so that the Commission can continue to make wise, and visionary, decisions about efficient RF spectrum allocation of a non-renewable national asset. This presentation is an overview of GPS as a national resource and emerging global information utility. It includes a brief status of the U.S. GPS industry, commercial markets, range of commercial applications in the physical infrastructure, emerging applications in the information infrastructure (NII), and various techniques (differential GPS, RTK). The content of this presentation is public information and will be made available to any public or private entity on request.

Radiopositioning techniques fall into two main categories: autonomous satellite-based (AVL) and restricted ground-based (AVM). The two attachments to this letter describe the system characteristics and deployment of these two techniques.

Global Positioning System. GPS is a satellite-based radionavigation system deployed and operated by the Department of Defense (DOD). The GPS system consists of the complete constellation of 24 satellites. GPS provides highly accurate three-dimensional position, velocity, and time to users continuously worldwide. GPS has been under development since 1973 at a U.S. Government investment of approximately \$12 billion. DOD declared GPS to be Initial Operation Capability (IOC) status in 1993. GPS is operated and made available by the cooperative effort of the DOD and Department of Transportation (DOT). National management and civilian access policy are articulated in the Federal Radionavigation Plan (FRP).



GPS Accuracy. Systems employing GPS as a component provide accuracies that range from the subcentimeter to hundreds of meters. Current systems fall into five basic categories: stand alone (100 meters), military stand alone or PY Code (15 meters), commercial differential (Coast Guard radiobeacons, FM subcarrier)(5 to 10 meters), local area Geographic Information System (GIS) grade differential (1 meter), and survey (.5 to 5 centimeters).

GPS Industry. The United States leads the GPS industry worldwide with more than seventy percent marketshare in four principal markets: navigation (land, sea, air); survey and mapping (geographic information systems, seismic, land survey); tracking (transit, public safety, Intelligent Vehicle Highway Systems (IVHS), fleet management, mobile computing); military (NDI). The financial market research firm, Strategic Technology Partners, has sized the GPS user equipment market worldwide at \$420 million in 1993 with expected growth to \$800 million in 1995. The total GPS market in 1989 was approximately \$40 million. This means that the industry has had a tenfold increase in dollars in five years, and more than a five hundred fold increase in volume. GPS products range from half-million dollar systems, which are sold to the seismic industry, to boards for under \$200, which are sold for vehicle tracking and marine navigation use.

Commercial GPS Applications (Partial List). The successful deployment of GPS technology in the Gulf War accelerated its adoption for use in revitalizing the national infrastructure. The FAA has just concluded a study on how to accelerate the adoption of GPS in the National Air Space. The Coast Guard is deploying differential GPS for harbor/harbor entrance navigation. Automatic Vehicle Location (AVL) systems for police and fire are already in place in several cities around the country. Denver is just starting the operational phase of a transit tracking system using GPS. Chicago has decided on the use of GPS for its 911 emergency response system. GPS was used by the Federal Emergency Management Agency (FEMA), state agencies, and the news media for both in-vehicle navigation and GIS data capture in the disaster assessment following the Los Angeles earthquake and the Malibu fires. In the commercial sector, private Paramedic Ambulance Providers, such as American Medical Response (AMR) are using GPS-equipped ambulances, continuously reporting their location, status, speed, and vital information to the 911 Emergency Medical Dispatch Center in Fremont, California. AMR is the Paramedic Ambulance provider to 3.9 million people in the San Francisco East Bay Area (coverage includes cities). Commercial use also includes courier pick-up and delivery services in the San Francisco Bay area and Los Angeles.

International Use of GPS (Partial). To date, the Japanese use of GPS has centered on the car navigation application. It is estimated that a total, in excess, of 15,000 receivers a month is going into Japanese cars. Toyota is offering GPS navigation as standard on its high-end Lexus, and there is an active aftermarket in Japan. Sony is planning a roll-out of a GPS-based car navigation system this fall in the U.S. General Motors is planning to launch an aftermarket product in the same timeframe. The Japanese have targeted extensive infrastructure use of GPS, in particular, kinematic use (dynamic use of GPS in the survey mode) for heavy construction, and extensions envisioned to control the airspace: landing and air traffic control.

Strategic Spectrum Use is Vital to the NII. Information technologies are a key determinant in the comparative advantage of national economies. The current global race is in integrating them into National Information Infrastructures (NII). A principal challenge in constructing the NII is to accommodate unborn information innovation on which the continuous competitive vitality of the NII depends. Spectrum is a non-renewal national asset and its strategic



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use is fundamental to the long-term competitive advantage of the NII, especially in fostering innovation. The current breadth of innovative activity, exhibited by the wide range of Part 15 users, indicates a healthy use of the 902-928 MHz Band by emerging technologies, that serves the public interest. Much of this vibrant innovation has potential for inclusion in the NII.

Conclusion. In conclusion, we believe that RF spectrum allocation should be driven by efficient use and should foster R&D in telecommunications. We recommend that 1) GPS is not only already available for, but superior to, many of the proposed AVM applications; 2) there is no need to carve out spectrum, since GPS applications already work in the current available spectrum, and 3) the cost to the national good of the AVM partition basically outweighs the proposed benefits, since it poses potential risk to the NII and to the continued exploitation of GPS as a national resource.

Respectfully submitted,

Charles R. Trimble
President

ATTACHMENT I

COMPARISON OF LOCATION SYSTEMS

AUTOMATIC VEHICLE LOCATION (AVL)

Real-Time

These systems "receive only" information from satellites and do not need to communicate back to compute not only position, but also speed, direction, time, and record (on board) historical data.

Geographically-Independent

GPS is a satellite-based global information utility that provides very precise, instantaneous, navigation, positioning, and timing information continuously worldwide. In AVL systems, GPS data can be computed, recorded, and transmitted on a nationwide basis.

Multi-Sensor "Friendly"

As a digital signal processing technology, GPS easily integrates ancillary sensor input such as inertial systems (dead-reckoning) which not only improves accuracy in low satellite visibility situations (urban canyons). This approach also provides a flexible, robust, and redundant system which is autonomous enough to function in case of major disasters affecting citywide infrastructures, such as earthquakes, hurricanes, or man-made power losses.

Non-Interfering. Frequency-Independent

AVL system operation has been performed using the widest range of available telecommunications technology. This has allowed leading edge telecommunication research to excel in advanced techniques, such as frequency hopping, Time-Division Multiple Access (TDMA), Code-Division Multiple Access (CDMA), and dynamic digital interference sensing.

AUTOMATIC VEHICLE MONITORING (AVM)

Near Real-Time

In order to generate an approximate location "fix" the vehicle has to be queried (no accurate speed or direction information is available due to the interrogative nature of the technique).

Site Dependent

Ground-based, pulse-ranging technique requires a complex network of towers, base stations and the "hand-off" backbone to operate. The economics are such that only large urban areas can be serviced.

Closed Architecture

AVM location monitoring is exclusively dependent upon overall network operational status. Direct infrastructural failure renders the system inoperational.

Frequency-Exclusive

A "carving" of the spectrum is required to permit AVM system operations. This will lead to slowing or altogether eliminating a broad range of emerging technologies, such as: electronic article surveillance; personal communication networks (digital cordless phones); wireless local area networks (wireless LAN); high speed public safety data networks for disaster recovery command and control; and, numerous emerging, low cost solutions for a wide range of consumers.

ATTACHMENT II

Table 1. Statistics on the number of IVHS navigation systems employing various positioning technologies

	GPS	DR	INS	SP	TRF	MM	RDSS
Used	72	68	2	14	22	35	4
Optional	13	1	0	11	7	0	0
Proposed	5	3	0	1	0	1	2
Total	90	72	2	25	29	36	6
Percentage	61	49	1	18	20	24	4

The total number of IVHS navigation systems developed worldwide between 1975 and 1993 is 148.
 DR — dead reckoning; INS — inertial navigation systems; SP — signpost; TRF — terrestrial radio frequency; MM — map matching; and RDSS — radio determination satellite service.

Table 2. Summary statistics on the types of systems used in selected regions of the world

		Autonomous	Fleet management	Advisory	Inventory	Total
North America	N	15	44	3	12	74
	%	20	59	4	16	100
Japan	N	17	1	12	1	31
	%	55	3	39	3	100
Europe	N	9	20	10	1	40
	%	23	50	25	3	100

A total of 145 systems from 1975 to 1993 for these three regions.

Table 3. Statistics on the positioning techniques used in selected regions of the world, excluding proposed sensors

		GPS	DR	INS	SP	TRF	MM	RDSS
North America	Single	29	3	0	1	10	0	2
	Multi	24	19	2	3	8	9	0
	Total	53	22	2	4	18	9	2
	%	72	30	3	5	24	12	3
Japan	Single	7	2	0	0	1	0	0
	Multi	7	20	0	9	0	17	0
	Total	14	22	0	9	1	17	0
	%	45	71	0	29	3	55	0
Europe	Single	7	4	0	2	4	0	2
	Multi	9	20	0	10	5	9	0
	Total	16	24	0	12	9	9	2
	%	40	60	0	30	23	23	5
Total	N	83	68	2	25	28	35	4
	%	57	47	1	17	19	24	3

A total of 145 systems from 1975 to 1993 for these three regions.
 DR — dead reckoning; INS — inertial navigation systems; SP — signpost; TRF — terrestrial radio frequency; MM — map matching; and RDSS — radio determination satellite service.